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DETERMINE THE FEASIBILITY OF GRINDING AND SLURRYING FEEDLOT MANURE FOR FIELD INJECTION

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Final Report

Determine the Feasibility of Grinding and Slurrying Feedlot Manure for Field Injection

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1. Summary

Feedlot manure is currently applied as a fertilizer by spreading on the surface of agricultural land, whereas hog manure is injected into the ground. Injection has several advantages over surface application. The goal of this project was to determine whether feedlot manure could have practical amounts of water added so that it could be land applied using existing hog manure injection equipment. The specific objective of the project was to determine the feasibility of slurrying and land application of feedlot manure or compost through a simulated pipeline/dragline system.

A vertical mixer attached to a Houle pump and pipeline system was configured to batch process and pump feedlot manure and feedlot compost. The mixer/pump/pipeline system was tested and baseline pump curve developed with water. Batches of manure/water and compost/water were weighed and mixed in the vertical mixer and the mixed slurry pumped through the pipeline at a range of pump rpm's. Pump curves were developed for each percent dry matter combination of manure and compost. Percent dry matter for manure and compost was increased until the slurry would not pump through the system.

The maximum dry matter pumped through the system was 11.4% for feedlot manure and 20.6% for compost. To simulate the manure volume applied by a typical feedlot custom cleaner operation, the minimum amount of water required to slurry feedlot manure was 578,000 gal/day for feedlot manure and 114,000 gal/day for compost.

It was concluded that the slurrying and pumping of feedlot manure was not practical due to the high volume of water required for pumping unless the feedlot is near a lake or river. In contrast, compost required less than one quarter of the water needed for feedlot manure and the compost was easier to slurry. Slurrying and pipeline/dragline application of compost may be practical provided sufficient water is available for the process.

2. Objectives

To develop and test the feasibility of grinding and slurrying feedlot manure to allow efficient transport and field injection through pipeline/drag hose or truck-based injection systems.

3. Project Description

A typical source of feedlot manure and composted feedlot manure from Termuende Farm was used for the slurry pumping tests. The manure and compost was sampled and oven dried at 105°C to determine moisture content (MC) on a wet weight (wt) basis (wet manure wt - dry manure wt/wet manure wt x 100). Oven dry MC was used to calculate water/manure and water/compost batches.

Testing was conducted on PAMI property in Humboldt from September 8 to 22, 2004. The test system consisted of a Supreme model 500 vertical mixer, Houle pump, flow meter, and pipeline system that was configured to simulate a pipeline/drag hose system that is typically used for emptying and field application of swine manure from an earthen manure storage (**Figures 1** and **2**).

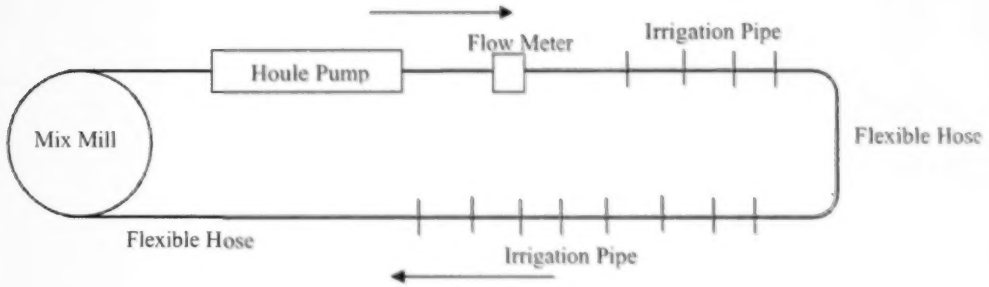

Figure 1. Schematic of Test System.

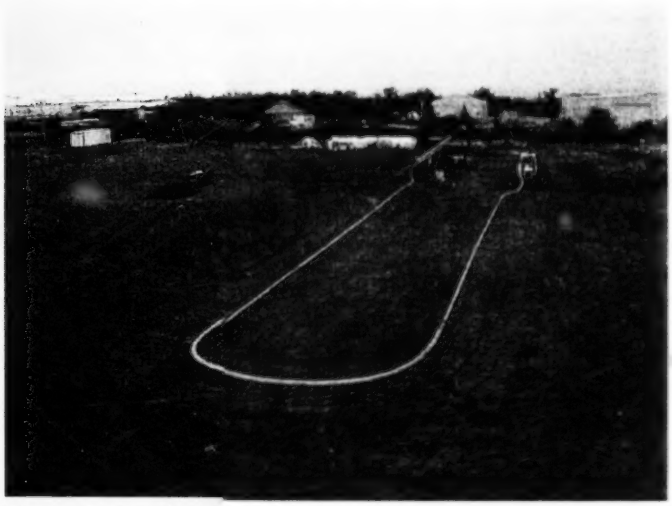

Figure 2. Overview of System.

Each manure or compost and water batch was mixed in a modified vertical mixture powered by PTO from a farm tractor. The mixer was equipped with load cells for accurate measurement of manure (or compost) and water in each slurry batch. Modifications to the mixer included sealing to minimize leakage and the addition of a 6 in. diameter outlet valve on the bottom of the mixer (**Figure 3**). The valve was attached to a rubber hose that directed the manure to the inlet of the Houle pump.

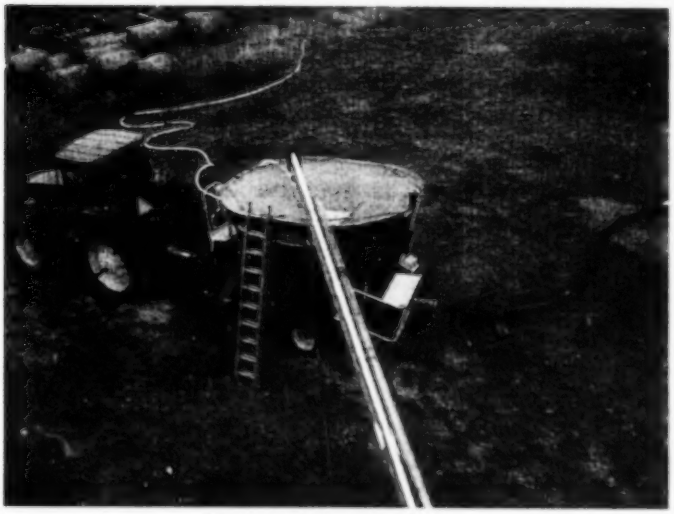

Figure 3. Supreme Vertical Mixer.

The Houle centrifugal pump used in the experiment was a standard manure agitation pump typically used for the agitation of swine earthen manure storages. This pump was powered by a farm tractor PTO. The pump was modified by the removal of the agitation propeller and the addition of a 6 in. inlet valve that attached to the bottom of the pump and connected to the discharge hose from the vertical mixer. The system was also sealed with tar and silicone to prevent air leaks into the pump. The Houle pump discharged the slurry through aluminium irrigation pipe and rubber hoses to the 6 in. diameter pipeline system (**Figure 4**).

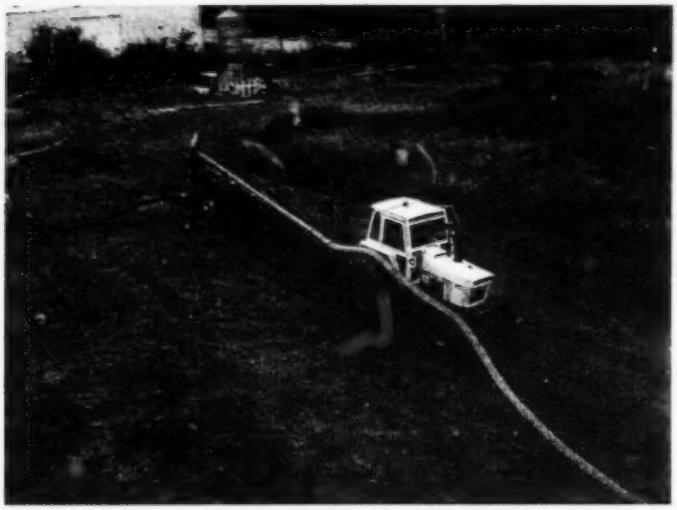

Figure 4. Houle Pump.

A flow meter and pressure gauges were connected to the pipeline system to measure slurry flow and pressure drop in the pipeline (**Figures 5** and **6**).

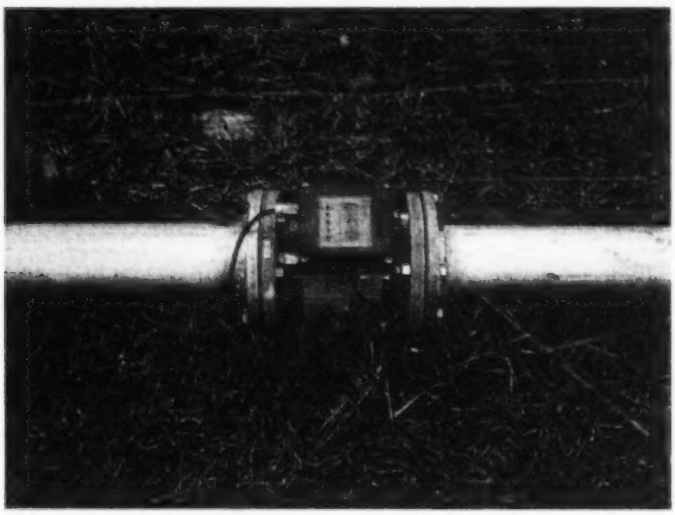

Figure 5. Flow Meter.

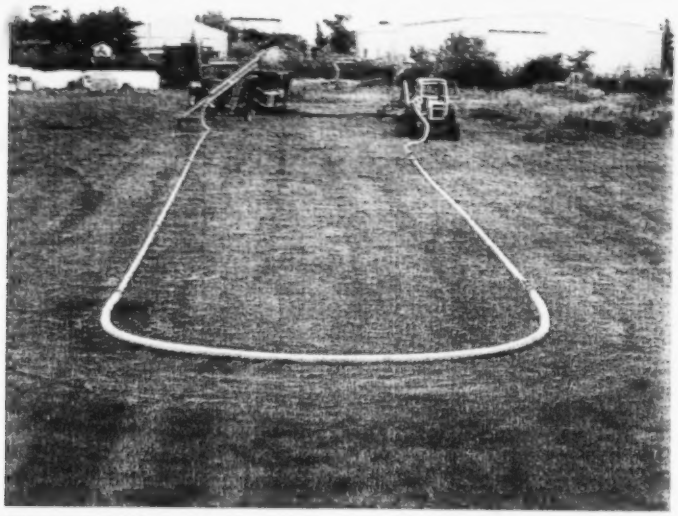

Figure 6. Pipeline System.

At the end of the pipeline, slurry was discharged from the end of the pipeline back into the top of the vertical mixer. During pumping, the slurry was continuously circulated throughout the closed loop system.

Each batch of water and manure or compost was weighed into the mixer, starting with water followed by manure or compost. Targeted dry matter started at 5% for the feedlot manure and 9.1% for the compost and was increased until the slurry would not flow. Once the correct ratio of water and manure or compost was added to the batch, the mixer was operated at PTO rpm for 10 minutes followed by 10 minutes of running the Houle pump and closed loop system. The Houle pump was operated at a range of rpm's with each batch and the flow and pressure drop recorded to develop pump curves. On completion of each test series, additional water and manure or compost was added to the batch to increase the percent dry matter and the testing was repeated at increasing dry matter content until the system would no longer pump.

4. Results and Discussion

Water was used to test the system and provide a baseline pump curve for the system (**Figure 7**).

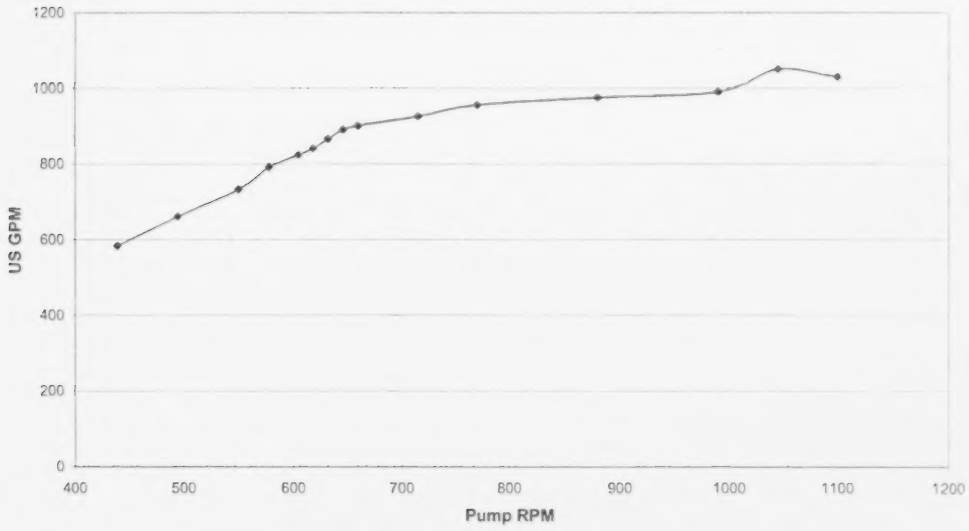

Figure 7. Water Pump Curve.

Water flow response to pump speed was linear from 400 to 700 rpm with a levelling of the curve above 700 rpm.

4.1 Feedlot Manure Pumping Tests

Feedlot manure testing started with 4.2% dry matter in the slurry. Water was added to the vertical mixer followed by the feedlot manure. Once the water/manure batch was loaded, the tractor PTO was brought to 1,000 rpm resulting in a rotor rotation speed of 34 rpm. The screw shaped agitator quickly mixed the manure and water with most manure or straw broken into small pieces with some fist size solids remaining in the suspension. Following 10 minutes agitation, the Houle pump was turned on and the valve on the bottom of the mixer opened to deliver slurry to the Houle pump. Once the pipeline was filled and the slurry discharging back into the mixer, the system was run for 10 minutes prior to beginning testing at a series of pump speeds. Flow volume and line pressure was measured at each pump speed. Additional water and manure was added to the original batch to achieve 8, 11.4, and 12% dry matter content slurry. Pump flow at each pump rpm was reduced as the percent dry matter increased until the slurry would not pump at 12% dry matter (**Figure 8**).

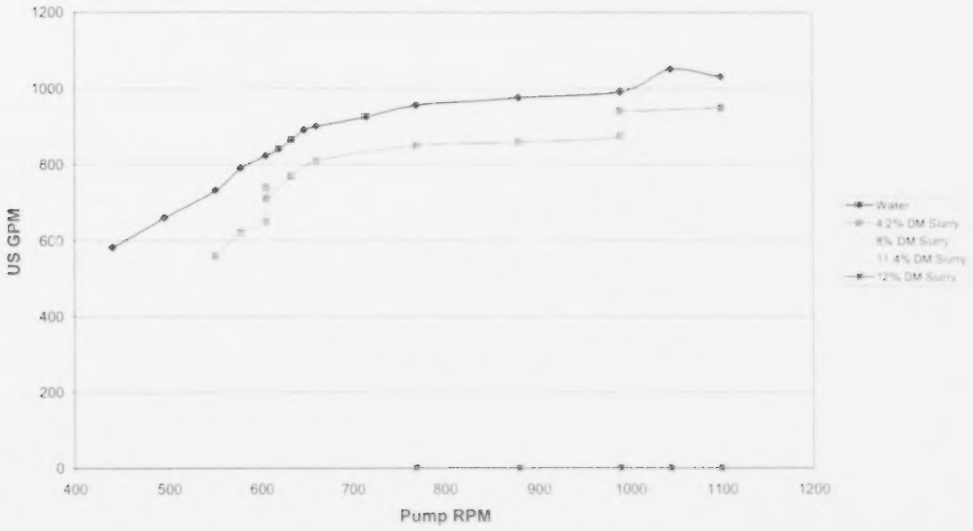

Figure 8. Effect of Feedlot Manure Dry Matter Content on Slurry Pumping Efficiency.

4.2 Compost Pumping Tests

On completion of the feedlot manure testing, the system was flushed with water and drained to prepare for compost testing. Test protocol was identical to that used for feedlot manure. Test batches started at 9.1% dry matter content and dry matter was increased incrementally until the slurry would not pump.

Similar to solid manure, compost slurry flow rate at each rpm was reduced as the percent dry matter increased until the slurry would not pump at a dry matter moisture content of 21.6%. This slurry batch was then diluted back to 20.6% where the batch would pump (**Figure 9**).

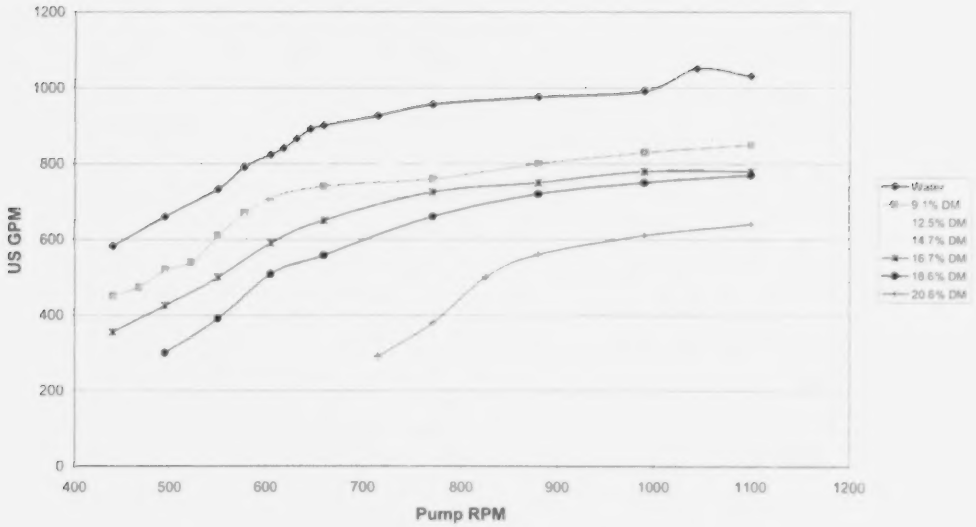

Figure 9. Effect of Compost Dry Matter Content on Pumping Efficiency.

Unlike the solid manure test, it was observed that the compost, when agitated with water, almost immediately broke into small particles and became a homogenous mixture with very few lumps on the surface. The rapid break-up of the compost was likely the reason that compost slurry would pump at a much higher dry matter content compared to feedlot manure.

As compost would not pump at 21.6% dry matter content, it can be concluded that the highest level of dry matter compost slurry that can be pumped is not much above 20.6% dry matter.

4.3 Feedlot Manure Analysis

These conclusions are based on the assumption that if a commercial pipeline/dragline system, typically used in the swine industry, is to be used for applying feedlot manure to the land, the system must be able to physically apply the same volume/wt of manure to the soil as a custom feedlot cleaning operation.

Based on information from the Western Beef Development Centre (WBDC), a typical custom feedlot cleaner will apply about 1,650 tons/day (wet wt) of feedlot manure. This is based on using six large tandem manure spreader trucks and a large loader with a maximum one way hauling distance of 2 miles (6 trucks x 275 tons/10 hr day). At a wet basis moisture content of 72.5%, the following calculation shows the wt of dry material applied to the field daily.

$$\frac{1{,}650 - drywt}{1{,}650} = 0.725$$

dry wt = 454 tons

If the feedlot slurry mixture is maximized at about 10% dry matter, then to apply 451 tons dry matter:

Slurry x 0.1 = 454

Slurry = 4,540 tons/day

As the manure contains 72.5% moisture content, then:

4,540 tons/day slurry = dry + water in manure + water added

4,540 tons/day = wet manure + water added

Slurry - wet manure = water added

4,540 - 1,650 = 2,890 tons water added

Therefore, to slurry and pump 1,650 tons/day of wet feedlot manure, it would require the addition of 2,890 tons/day of added water.

4.4 Compost Analysis

Compost has the advantages of both a reduction in volume and weight of about 50% compared to feedlot manure and when slurried, will pump at a much higher percent dry matter.

As the volume of wet compost is about 50% of feedlot manure, then the commercial feedlot manure application rate will be reduced from 451 dry tons/day to 225 dry tons/day. If the compost slurry mixture is maximized at about 20% dry matter, then the slurry application rate is as follows:

Slurry x 0.20 = 225 tons/day

Slurry = 1,125 tons/day

However, the compost contains 59.5% water an wet wt basis, then:

$$\frac{w - d}{w} = 0.595$$

$$\frac{w - 225 tons/day}{w} = 0.595$$

wet compost = 555 tons/day

1,125 tons slurry/day = wet compost + water added

water added = 570 tons/day

Therefore, to slurry and pump 555 tons/day of wet compost, it would require the addition of 570 tons/day water for a total of 1,125 tons/day of slurry.

5. Conclusions

5.1 Feedlot Manure

Commercial hog pipeline/dragline systems have the capability of applying about 5,000 tons (1 million Imperial gallons) of hog manure/day. As the feedlot manure slurry requirement is slightly less than that, it is physically possible to apply the target rate of feedlot manure slurry through a pipeline/dragline system. However, the requirement of adding 2,890 tons/day or 578,000 Imperial gallons of water/day makes the slurrification of feedlot manure impractical unless the feedlot is near a lake or river. Another potential source to increase moisture content would be mixing feedlot manure with hog manure. However, this would require considerable amounts of hog manure. Also, from a practical perspective, this would require the two operations to be reasonably close, and there would be the challenges of coordination, development of mixing equipment, and understanding the agronomics.

5.2 Compost

Compost requires much less water added to produce a pumpable slurry compared to feedlot manure slurry at 570 tons or 114,000 Imperial gallons/day. As this system uses less than 25% of the water required for the feedlot manure system, there may be a practical application of slurried compost provided enough water is available for the process.

6. Personnel

6.1 PAMI Manpower Supplied

It is PAMI's policy not to release individual salary information. The charge rates shown are the average salaries and benefits for each category of employee and are as shown in the ADF application. The benefit and overhead costs associated with salaries are partially to the PAMI applicant contribution and part of overhead is applied to other project costs.

7. ICAR Data Entry

The associated ICAR number with this project is #33331361.